INSIGHTS INTO THE MARTIAN REGOLITH FROM MARTIAN METEORITE NORTHWEST AFRICA 7034

Francis M. McCubbin[1,2], Jeremy W. Boyce[3], Timea Szabó[4], Alison R. Santos[2], Gabor Domokos[4], Jorge Vazquez[5,6], Desmond E. Moser[7], Douglas J. Jerolmack[8], Lindsay P. Keller[9] and Romain Tartèse[10,11]

[1]NASA Johnson Space Center, Mailcode XI, 2101 NASA Parkway, Houston, Texas 77058, USA
[2]Institute of Meteoritics, University of New Mexico, 200 Yale Blvd SE, Albuquerque, NM, 87131, USA.
[3]Department of Earth and Space Sciences, University of California, Los Angeles, California 90095-1567, USA.
[4]Department of Mechanics, Materials and Structures, Budapest University of Technology and Economics, Budapest, Hungary.
[5]United States Geological Survey, 345 Middlefield Road, Mail Stop 910, Menlo Park, CA 94025, USA.
[6]Stanford-USGS Ion Microprobe Laboratory, Stanford University, CA 94305, USA.
[7]Department of Earth Sciences, University of Western Ontario, 1151 Richmond Street, London, Ontario N6A 5B7, Canada.
[8]Department of Earth and Environmental Science, University of Pennsylvania, Philadelphia, PA 19104, USA.
[9]Laboratory for Space Sciences, Mail Code XI, ARES, NASA Johnson Space Center, Houston, Texas, USA
[10]Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie, Muséum National d'Histoire Naturelle, Sorbonne Universités, CNRS, UMPC & IRD, 75005 Paris, France
[11]Department of Physical Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK.

Corresponding author email: francis.m.mccubbin@nasa.gov

Everything we know about sedimentary processes on Mars is gleaned from remote sensing observations. Here we report insights from meteorite Northwest Africa (NWA) 7034, which is a water-rich martian regolith breccia that hosts both igneous and sedimentary clasts. The sedimentary clasts in NWA 7034 are poorly-sorted clastic siltstones that we refer to as protobreccia clasts. These protobreccia clasts record aqueous alteration process that occurred prior to breccia formation. The aqueous alteration appears to have occurred at relatively low Eh, high pH conditions based on the co-precipitation of pyrite and magnetite, and the concomitant loss of SiO2 from the system. To determine the origin of the NWA 7034 breccia, we examined the textures and grain-shape characteristics of NWA 7034 clasts. The shapes of the clasts are consistent with rock fragmentation in the absence of transport. Coupled with the clast size distribution, we interpret the protolith of NWA 7034 to have been deposited by atmospheric rainout resulting from pyroclastic eruptions and/or asteroid impacts. Cross-cutting and inclusion relationships and U-Pb data from zircon, baddelleyite, and apatite indicate NWA 7034 lithification occurred at 1.4-1.5 Ga, during a short-lived hydrothermal event at 600-700 °C that was texturally imprinted upon the submicron groundmass. The hydrothermal event caused Pb-loss from apatite and U-rich metamict zircons, and it caused partial transformation of pyrite to submicron mixtures of magnetite and maghemite, indicating the fluid had higher Eh than the fluid that caused pyrite-magnetite precipitation in the protobreccia clasts. NWA 7034 also hosts ancient 4.4 Ga crustal materials in the form of baddelleyites and zircons, providing up to a 2.9 Ga record of martian geologic history. This work demonstrates the incredible value of sedimentary basins as scientific targets for Mars sample return missions, but it also highlights the importance of targeting samples that have not been overprinted by metamorphic processes, which is the case for NWA 7034.